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<b>(21) International Application Number:</b> PCT/US00/02714 <b>(22) International Filing Date:</b> 3 February 2000 (03.02.00)  <b>(30) Priority Data:</b> 09/244,711 4 February 1999 (04.02.99) US 09/384,464 27 August 1999 (27.08.99) US  <b>(71) Applicant:</b> OMNOVA SOLUTIONS INC. [US/US]; 175 Ghent Road, Fairlawn, OH 44333 (US).  <b>(72) Inventors:</b> WEINERT, Raymond, J.; 8472 Bobolink Drive, Macedonia, OH 44056 (US). KRESGE, Edward, N.; 68 Parlin Lane, Watchung, NJ 07060 (US). MEDSKER, Robert, E.; 13145 Kaufman Avenue, N.W., Hartville, OH 44632 (US). WOODLAND, Daniel, D.; 84 Wilbur Drive, Munroe Falls, OH 44262 (US).  <b>(74) Agents:</b> RYWALSKI, Robert, F.; Omnova Solutions, Inc., 175 Ghent Road, Akron, OH 44333 (US) et al.		<b>(81) Designated States:</b> CA, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
<b>(54) Title:</b> POLYESTER WITH PARTIALLY FLUORINATED SIDE CHAINS  <b>(57) Abstract</b>  A polyester polymer including at least one polyoxetane block of repeating units derived from polymerizing at least one oxetane monomer having at least one pendant $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$ Rf group wherein said Rf group is partially or fully fluorinated is described. A preferred process for forming said polymer by reacting the hydroxyl terminated polymer with a polycarboxylic acid under appropriate conditions to form an ester linkage and then adding and reacting that product with polyester forming reactants.		

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5           **POLYESTER WITH PARTIALLY FLUORINATED SIDE CHAINS**

          This application is a continuation-in-part of prior application  
Serial Number 09/244,711, filed February 4, 1999, entitled Easily  
Cleanable Polymer Laminates which was a continuation in part of prior  
10 application Serial Number 09/035,595, filed March 05, 1998, entitled  
Easily Cleanable Polymer Laminates, both of which are herein incorpo-  
rated by reference.

**FIELD OF INVENTION**

15           This invention relates polyester polymers including blocks of  
polyoxetane derived from polymerizing monomer or monomers including  
oxetane monomers with partially fluorinated side chains. These polyes-  
ters have many of the desirable properties of fluorinated polymers and  
the ease of processability of the polyesters. The desirable properties of  
20 the fluorinated polymers are due to the partially fluorinated side chains  
and the tendency of the fluorinated side chains to be disproportionately  
present at any surfaces generated. These polymers are preferred in  
some embodiments over polyoxetanes with the partially fluorinated side  
chains as they are more easily incorporated and bound into a variety of  
25 polymers due to the polyester portion of the polymer.

**BACKGROUND OF INVENTION**

          U.S. Patent 5,650,483 describes the preparation of oxetane  
monomers useful to form oxetane polymers with pendant fluorinated  
30 chains. The oxetane polymers were characterized as having low sur-  
face energy, high hydrophobicity, and a low coefficient of friction. That  
patent is incorporated by reference herein for its teachings on how to  
prepare the oxetane monomers and polymers. In the reference the  
oxetane polymers could be formulated with isocyanates to form  
35 crosslinked compositions. Additional patents issued on variations of the  
oxetane monomers and polymers. These were U.S. 5,468,841;

5,654,450; 5,663,289; 5,668,250, and 5,668,251 also incorporated herein by reference.

Polyesters are a very useful class of polymers. They are used as molding or extruding polymers, as solvent or water dispersible polymers in coatings which can be cured with amino resins, as components in polyurethanes and epoxy materials, and when they are unsaturated in thermoset molding compositions for a variety of filled and/or fiber reinforced applications.

#### SUMMARY OF INVENTION

According to the present invention, it was discovered that a polyester resin having low surface energy, high hydrophobicity and a low coefficient of friction, which can result in improved stain and abrasion resistance, is produced by incorporating a hydroxyl terminated polymer (blocks) having repeating units from an oxetane monomer having pendant fluorinated groups thereon into a polyester. The hydroxyl terminated polymer may have other repeat units such as derived from the ring opening polymerization of cyclic ethers including tetrahydrofuran, propylene oxide or epoxy monomers. A preferred method of incorporating the polyoxetane into the polyester is to react the polyoxetane with a dicarboxylic acid or anhydride thereof under effective conditions to result in a half ester linkage between the polyoxetane and the diacid along with carboxylic acid terminal groups. Thereafter additional polyester repeating units can be added by reacting the terminal carboxylic acid groups with polyols or cyclic ethers and additional polyacids and/or anhydrides of polyacids. As polyesters are known to undergo ester interchange reactions one could generically list the reactants used to form the polyesters as polyesters and their precursors.

The preferred oxetane monomer for this application can have a single pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf group where the Rf group is a partially or fully fluorinated linear or branched alkyl of from 1 to 20 carbon atoms, R is hydrogen or an alkyl of 1 to 6 carbon atoms, and n is from 1

to 3. Polyoxyetanes with two pendant partially fluorinated groups per repeating unit could also be used with this technology. The terminology "partially fluorinated pendant group" will be used to describe the  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-\text{Rf}$  group which is only partially fluorinated due to the  $\text{CH}_2$  and  $-(\text{CH}_2)_n$  portions.

#### DISCUSSION OF DETAILS AND PREFERRED EMBODIMENTS

The polyester resins are generally made by a condensation polymerization reaction, usually with heat in the presence of a catalyst, of a mixture of a polycarboxylic acid or its anhydride and a polyhydric alcohol. Preferred polycarboxylic acids are the dicarboxylic acids and their anhydrides. Fatty monobasic oils or fatty acids, monohydroxy alcohols and anhydrides may be present. The polyester may contain active hydrogen atoms, e.g., carboxylic acid groups and/or hydroxyl groups for reaction with the amino resin or may contain unsaturation for crosslinking by another mechanism such as copolymerization with ethylenically unsaturated monomers. Examples of some acids to use to form the alkyd resin or reactive polyester are adipic acid, azelaic acid, sebacic acid, terephthalic acid, phthalic anhydride, and so forth. Generally the aliphatic carboxylic acids have from about 3 to about 10 carbon atoms. Other carboxylic acids such as carbonic acid or phosgene may be used in lieu of carboxylic acids under appropriate conditions. The aromatic carboxylic acids generally have from about 10 to about 30 carbon atoms. The polyhydric alcohols (polyols) generally have from about 2 to about 20 carbon atoms and from about 2 to about 5 hydroxyl groups. Polymeric polyols such as formed from the polymerization of cyclic alkylene oxides may be used as a portion or all of the polyhydric alcohol. Polymeric polyols generally have number average molecular weights from 100 to 5,000 or 10,000. Examples of some polyhydric alcohols include ethylene glycol, propylene glycol, diethylene glycol, dipropylene glycol, glycerine,

butylene glycol, 2,2-dimethyl-1,3-propanediol, trimethylol propane, 1,4-cyclohexanedimethanol, pentaerythritol, trimethylolethane and the like. Mixtures of the polyols and polycarboxylic acids can be used. An example of a suitable reactive polyester is the condensation product of trimethylol propane, 2,2-dimethyl-1,3-propanediol, 1,4-cyclohexanedimethanol, phthalic anhydride and adipic acid. Mixtures of these reactive polyesters (alkyd resins) can be used. Alkyd resins are well known as shown by the "Encyclopedia of Polymer Science and Technology," Vol. 1, 1964, John Wiley & Sons, Inc., pages 663-734; "Alkyd Resins," Martens, Reinhold Publishing Corporation, New York, 1961 and "Alkyd Resin Technology," Patton, Interscience Publishers, a division of John Wiley and Sons, New York, 1962. Some unsaturated polycarboxylic acids and unsaturated polyols may be used in the condensation reaction.

The polyester segments of the polyester may also be polymerized from cyclic ethers typically containing 2 or 3 carbon atoms in the ring and an anhydride (e.g. an unsaturated anhydride) using double metal complex cyanide catalysts. These polyesters can be used with a carboxylic half ester functionalized polyoxetane because of the occurrence of ester interchange reactions whereby polyester polymers cleave to form carboxylic acid and hydroxyl end groups and then couple with other polyester fragments via an ester linkage. Generally any cyclic oxide can be utilized such as 1,2-epoxides, oxetanes, and the like, with the cyclic ether having a total of up to 18 carbons atoms, as for example 2 carbon atoms in the ring and up to 16 carbon atoms in the side chains. Such cyclic oxide monomers can also contain one or more aliphatic double bonds. Generally five-member unsaturated cyclic anhydrides are preferred, especially those having a molecular weight between 98 and 400. Mixed anhydrides can be used. Anhydrides include phthalic, itaconic, nadic etc. Halogenated anhydrides can also be used. Such polyesters are known to the art and de-

scribed in U.S. Pat. No. 3,538,043 which is hereby incorporated by reference.

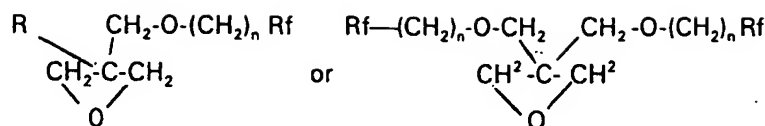
Amino resins can be used as a crosslinker (curative) for the polyester when it has terminal hydroxyl and/or carboxylic acid groups.

- 5 These amino resins generally include alkylated benzoguanamine-formaldehyde, alkylated urea-formaldehyde, or preferably alkylated melamine-formaldehyde resin. Mixtures of these resins can be used. These amino resins are well known and include those set forth in "Aminoplastics," Vale et al, Iliffe Books Ltd., London, 1964; "Amino  
10 Resins," Blair, Reinhold Publishing Corporation, New York, 1959, "Modern Plastics Encyclopedia 1980-1981," pages 15, 16 and 25 and "Encyclopedia of Polymer Science And Technology," John Wiley & Sons, Inc., Vol. 2, 1965, pages 1 to 94.

- If amino resins are used as curatives (crosslinkers) sufficient  
15 amounts by weight of the reactive polyester and amino resin are employed to provide a stain resistant, good durability and flexibility and good adhesion to a substrate if used in a laminate. These materials are desirably cured at temperatures of at least 150, 200, 250 or 400°F or more (66, 93, 121, or 204°C) for effective times in the  
20 presence of a minor amount by weight of an acidic catalyst such as boric acid, phosphoric acid, acid sulfates, hydrochlorides, phthalic anhydride or acid, oxalic acid or its ammonium salts, sodium or barium ethyl sulfates, aliphatic or aromatic sulfonic acids such as p-toluene sulfonic acid (preferred), methane sulfonic acid and the like.

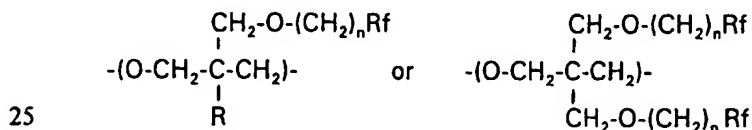
- 25 The hydroxyl terminated polymer(s) including repeating units from an oxetane having at least one pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-\text{Rf}$  group are prepared from the polymerization of oxetane monomer with partially fluorinated side chains. These polyoxetanes can be prepared according to the teachings of U.S. Patents 5,650,483; 5,668,250 and  
30 5,663,289 hereby incorporated by reference for those teachings. The oxetane monomer desirably has the structure

5



- 10 wherein each  $n$  is the same or different and independently is an integer from 1 to 3 and each  $\text{Rf}$  is the same or different and independently, on each monomer is a linear or branched alkyl group of 1 to 20 carbon atoms with a minimum of 25, 50 or 75 percent of the H atoms of each said  $\text{Rf}$  being replaced by F, or each  $\text{Rf}$  is the same or different
- 15 and, independently, is an oxaperfluorinated polyether having from 4 to 60 carbon atoms;  $\text{R}$  being H or an alkyl of 1 to 6 carbon atoms; preferably each  $\text{Rf}$  is the same or different and independently has at least 85, more preferably at least 95% of said H atoms replaced by F, and most preferably is perfluorinated. Preferably said linear or branched
- 20 alkyl group is of from 1 to 10, or 25 carbon atoms.

The repeating units from said oxetane monomers desirably have the structure



25

where  $n$ ,  $\text{Rf}$ , and  $\text{R}$  are as described above.

- The hydroxyl-terminated polymer(s) including repeating units from said oxetane monomers can have one or more terminal hydroxyl groups. They desirably have number average molecular weights from
- 30 about 250, 1,000 or 5,000 to about 50,000. The polymer(s) can be a homopolymer or a copolymer of two or more different oxetane



monomers. The polymer may also be a copolymer including non-fluorinated cyclic ether molecules having from 2 to 4 carbon atoms in the ring such as tetrahydrofuran and one or more oxetane monomers as described in the previously incorporated U.S. patent 5,668,250.

- 5 The copolymer may also include copolymerizable substituted cyclic ethers such as substituted tetrahydrofuran. The repeating unit from a tetrahydrofuran monomer has the formula to  $-(O-CH_2-CH_2-CH_2-CH_2-)$ . The hydroxyl-terminated polymer optionally includes a cyclic oligomer of said oxetane monomer which may be a byproduct of the polymerization.
- 10 zation. In some embodiments, said hydroxyl terminated polymer includes up to 10, 20 or 30 wt % of said tetramer based on the weight of said hydroxyl terminated polymer(s).

- It is desirable that the polymer including repeating units from an oxetane having at least one pendant  $-CH_2-O-(CH_2)_n-R_f$  group has
- 15 one or more hydroxyl groups in that this provides a possible mechanism for this polymer to be chemically bound into the polyester. The relative amount of bound and fugitive partially fluorinated polyoxetane has not been measured in some prior polyester compositions and the bound portion may be a small or large percentage of the total oxetane
- 20 repeating units.

- It is desirable to prereact the hydroxyl terminated partially fluorinated polyoxetane (polyoxetane block) with the polyester forming components to increase the percentage of partially fluorinated polyoxetane that is bound into the polyester or other polymer. It is highly
- 25 preferred to react the hydroxyl terminated partially fluorinated polyoxetane with at least 2 moles of carboxylic acid from a polycarboxylic acid or its anhydride per mole of hydroxyl groups from any polyol component under conditions effective to form an ester condensation product from the hydroxyl group of the polyoxetane and the carboxylic acid group of the polycarboxylic acid or its anhydride, more desirably the moles of carboxylic acid groups is at least 2.10 or 2.2 per
- 30

mole of hydroxyl groups. In a preferred embodiment the amount of non-fluorinated polyol is small or zero to force the carboxylic acid groups to react with the hydroxyl group of the partially fluorinated polyoxetane. Desirably the moles of hydroxyls from non-fluorinated polyols are less than 0.5, more desirably less than 0.2 and preferably less than 0.1 per mole of hydroxyls from the partially fluorinated polyoxetane until after at least 25, 70, or 90 mole percent of the hydroxyl groups of the polyoxetane are converted to half esters with the polycarboxylic acid. It is also acknowledged that the percentage of the polymer (blocks) with said oxetane repeating units and the oxetane repeating units themselves may not be uniformly distributed through the bulk of the polyester. Said oxetane repeating units (blocks) are preferably disproportionately present at the surface of the coating due to the low surface tension of those repeating units. The amount of surface fluorine groups can be determined by XPS (x-ray photoelectron spectroscopy).

Alternatively the hydroxyl terminated partially fluorinated polyoxetane can be coupled to polyester blocks or polyester forming components via urethane linkages derived from the reaction of isocyanate groups from a di or polyisocyanate compound with the hydroxyl groups of the polyoxetane and hydroxyl groups of the polyester. This would preferably be accomplished by the sequential reaction of a polyisocyanate with the hydroxyl groups of the hydroxyl terminated partially fluorinated polyoxetane to form an isocyanate terminated partially fluorinated polyoxetane. This would be favored by controlling the reaction so that at least 2 moles of isocyanate groups are present per mole of hydroxyl groups from the hydroxyl terminated partially fluorinated polyoxetane. Again it would be desirable to conduct the functionalization reaction in the absence of non-fluorinated polyols or limit the polyols to those amounts limited in the polyester coupling reaction to force a reaction between the isocyanates and the poly-

oxetane. After the isocyanate-terminated polyoxetane is formed (desirably at least 25, 50, 70 or 90 mole percent of the hydroxyls of the polyoxetane would be converted to urethane linkages) the polyester blocks could be added by two alternative procedures. A diol or polyol  
5 could be reacted with the isocyanate terminated polyoxetane to form a hydroxyl terminated polyoxetane, and thereafter additional diacids and diols could be added to the urethane functionalized polyoxetane through traditional ester forming reactions as previously taught. Alternatively the isocyanate terminated polyoxetane could be reacted  
10 with preformed polyesters (made by condensation or catalyzed ring opening polymerizations) to add polyester blocks via a second urethane linkage from the second isocyanate group of the polyisocyanate. The number average molecular weight of the polyester blocks, whether preformed or formed in situ, and whether added via ester  
15 linkages or urethane linkages would desirably be from about 100 to 5,000 or 20,000. It is understood that in all these reactions the possibility exists that some of the polyester molecules will not include any polyoxetane.

Alternatively to first reacting the di or polyisocyanate compound with the polyoxetane, one could first react the isocyanate compound with a polyester forming reactive isocyanate groups on the polyester and then coupling the reactive isocyanate groups on the polyester with the hydroxyl groups on the polyoxetane. It is anticipated that this  
20 alternative reaction scheme would not be as effective in coupling the polyoxetane to the polyester as the reactions between the di or polyisocyanate first with the polyoxetane.  
25

The di or polyisocyanate compound can generally be any compound of the formula  $X-(NCO)_y$ , where  $y$  is an integer above 2 and  $X$  is an aliphatic group of 4 to 100 carbon atoms, an aromatic group of  
30 6 to 20 carbon atoms, or a combination of alkyl and aromatic groups or alkyl substituted aromatic or aromatic substituted alkyl of 7 to 30 car-

bon atoms or the di or polyisocyanate compound could be oligomers thereof. These isocyanate compounds are well known to the art. Preferred ones are 4',4-methylene diphenyl isocyanate (MDI) as well as polymeric MDI, which is a liquid rather than a crystalline solid, toluene diisocyanate, 1,6-hexane diisocyanate, isophorone diisocyanate (pre-ferred), trimethylhexane diisocyanate, etc.

The amount of partially fluorinated polyoxetanes in said polyester is desirably from about 0.05 or 0.1 to about 10, 15 or 50 weight percent based on the weight of the polyester including the polyoxetane portion. The polyester can be diluted with other components (including non-fluorinated polyesters) while preparing a coating or other polymer composition. The repeating units from a polyester are desirably from about 50 to about 99.8 weight percent of the polyester and more desirably from about 85 or 90 to about 99 weight percent. The amount of the oxetane repeating units having at least one pendant  $\text{CH}_2\text{-O-(CH}_2\text{)}_n\text{Rf}$  group is desirably from about 0.05 or 0.1 to about 10 or 15 parts by weight and more desirably from about 0.1 to about 10 or 15 parts by weight per 100 parts total weight of the final coating or molded article from these polyesters. Of course if the hydroxyl terminated polymer(s) including repeating units from said oxetane has a significant amount of repeating units from tetrahydrofuran or other repeating unit therein, the hydroxyl terminated polyoxetane's weight will exceed that of said oxetane repeating units.

Additionally other conventional additives may be formulated into the polyester for particular applications. Examples include viscosity modifiers, antioxidants, antiozonants, processing aids, pigments, fillers, ultraviolet light absorbers, adhesion promoters, emulsifiers, dispersants, solvents, crosslinking agents, etc.

The polyesters may be used in any traditional polyester application including as a molding material or a coating material. When used as a coating material the substrates may be any material, which

would benefit from a low surface energy, hydrophobic properties including stain resistance or dry-erase, and low coefficient of friction. Examples of substrates that can be coated with coating compositions derived from these polyesters include cellulosic products (coated and  
5 uncoated paper, boardstock, cardboard, wood and paneling); fibers; synthetic polymers (including polyolefins, polyesters, polycarbonates, polystyrene, poly (methacrylates) and especially highly filled or highly plasticized ones which are more porous towards stains e.g. polyvinyl chloride); metals (requiring temporary or permanent protection from  
10 stains); and ceramics.

The polyesters of this application are useful as components in molding resins, components in coating, etc where low surface tension and/or low coefficient of friction is desired. The amount of partially fluorinated oxetane repeating units can be controlled by varying  
15 their content in the polyoxetane or by varying the amount of polyester components. The polyesters can include hydrophobic or hydrophilic (or polar and/or nonpolar) moieties to vary the compatibility of the polyester with other components. The polyester can be used as a thermoplastic resin or reacted into thermoset compositions (e.g. thermoset polyester-amine, polyurethane, or epoxy).  
20

The polyesters of the present invention are particularly useful in preparing dry erase writing surfaces (including boards, posters, papers, clipboards, menus, etc.) wallcoverings, anti graffiti surfaces e.g. in public areas including restrooms, and in kitchens and food  
25 preparation areas. Stain resistant laminates from these polyesters, can be used in the manufacture of tablecloths, shoe uppers, luggage exteriors, upholstery, vehicle interiors and seats, golf bags and other sporting goods and so forth.

The following examples will serve to illustrate the present  
30 invention with more particularity to those skilled in the art.

### Preparation of Poly-Fox Materials (U.S. 5,650,483)

A 10 L jacketed reaction vessel with a condenser, thermocouple probe, and a mechanical stirrer was charged with anhydrous methylene chloride (2.8 L), and 1,4-butanediol (101.5 g, 1.13 moles).  
5     $\text{BF}_3\cdot\text{THF}$  (47.96 g, 0.343 moles) was then added, and the mixture was stirred for 10 minutes. A solution of 3-Fox (3,896 g, 21.17 moles) in anhydrous methylene chloride (1.5 L) was then pumped into the vessel over 5 hours. The reaction temperature was maintained between 38 and 42 °C throughout the addition. The mixture was then  
10    stirred at reflux for an additional 2 hours, after which  $^1\text{H}$  NMR indicated >98% conversion. The reaction was quenched with 10% aqueous sodium bicarbonate (1 L), and the organic phase was washed with 3% aq. HCl (4 L) and with water (4 L). The organic phase was dried over sodium sulfate, filtered, and stripped of solvent under reduced pressure to give 3,646 g (91.2%) of title glycol, a clear oil.  
15    NMR: The degree of polymerization (DP) as determined by TFAA analysis was 15.2 which translates to an equivalent weight of 2804. The THF content of this glycol, as determined by  $^1\text{H}$  NMR, was 2.5% wt THF (6.2% mole THF). This example was included to teach how  
20    to polymerize partially fluorinated oxetane polymers.

### EXAMPLE I (FOX CONTAINING POLYESTER)

Two different hydroxyl terminated partially fluorinated polyoxetanes were used to prepare four different polyester materials according to this invention. The first polyoxetane had 6 mole % repeating  
25    units from tetrahydrofuran (THF) with the rest of the polymer being initiator fragment and repeating units from 3-FOX where  $n = 1$ ,  $\text{Rf}$  is  $\text{CF}_3$ , and  $\text{R}$  is  $\text{CH}_3$ . The number average molecular weight of the first polyoxetane was 3400. The second polyoxetane had 26 mole % of its repeating  
30    units from tetrahydrofuran with the residual being the initiator fragment and repeating units from 3-FOX. 3-FOX is also known as 3-

(2,2,2-trifluoroethoxymethyl)-3-methyloxetane.

#### EXAMPLE II (COATINGS FROM THE POLYESTER)

The first and second oxetane polymers were reacted at least a 2 equivalent excess (generally 2.05-2.10 excess) of adipic acid in a reactor at 455 F for 3.5 hours to form a polyoxetane having the half ester of adipic acid as endgroups. NMR analysis was used to confirm that substantially all the hydroxyl groups were converted to the ester groups. The average degree of polymerization of the first oxetane polymer was reduced from 18 to 14 during the reaction with adipic acid. The average degree of polymerizations of the second oxetane polymer remained at 18 throughout the reaction. The reactants were then cooled to 300 F.

The adipic acid functionalized polyoxetane was then reacted with additional diacids and diols to form polyester blocks. The diacids were used in amounts of 24.2 parts by weight of adipic acid and 24.5 parts by weight of isophthalic acid relative to the diols which were used in amounts of 20.5 parts by weight of cyclohexanedimethanol, 14.8 parts by weight of neopentyl glycol, and 16.0 parts by weight of trimethylol propane. The relative amounts of the adipate ester of the oxetane polymer and the polyester forming components was adjusted to result in polyesters with either 2 or 4 weight percent of partially fluorinated oxetane repeating units. The reaction temperature was lowered to 420 F for the additional diacids and diols. The reaction was continued until the calculated amount of water was generated. The finished batch sizes were from 20 to 30 gallons.

The four polyesters (2 or 4 wt.% oxetane and 6 or 26 mole percent of the polyoxetane being repeating units from THF) were formulated into solvent based coating compositions as shown in Table 1. The Resimene 747 resin is an amino resin curative for polyester resins. The PTSA is paratoluene sulfonic acid catalyst (40 Wt.% active in isopropanol). The coating compositions varied in the amount of poly-

oxetane in the polyester, the amount of tetrahydrofuran repeating units in the polyoxetane, and the weight ratio of Resimene (melamine formaldehyde curative) to polyester.



TABLE I

Components	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
n-propyl acetate	8.3	8.3	8.3	8.3	8.5
THF	.925	10.9	10.9	10.9	10.9
Polyester 2 wt.% 1st oxetane	18.95	0	0	0	16.8
Polyester 4 wt.% 1st oxetane	0	0	0	18.95	0
Polyester 2 wt.% 2 <sup>nd</sup> oxetane	0	18.95	0	0	0
Polyester 4 wt.% 2 <sup>nd</sup> oxetane	0	0	18.95	0	0
Resimene 747	18.55	18.55	18.55	18.55	20.15
PTSA	3.3125	3.3125	3.3125	3.3125	3.6
Surface F of the cured coating in atomic %	N/A	14.4	15.8	18.4	18.9

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TABLE I (continued)

Components	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
n-propyl acetate	8.5	8.5	8.5	8.75	8.75
THF	10.9	10.9	10.9	11.0	11.0
Polyester, 2 wt.% 1st oxetane	0	0	0	0	0
Polyester, 4 wt.% 1st oxetane	0	0	16.8	14.6	0
Polyester, 2 wt.% 2 <sup>nd</sup> oxetane	16.8	0	0	0	0
Polyester, 4 wt.% 2 <sup>nd</sup> oxetane	0	16.8	0	0	14.6
Resimene 747	20.15	20.15	20.15	21.75	21.75
PTSA	3.6	3.6	3.6	3.9	3.9
Surface F of the cured coating in atomic %	15.6	17.2	18.8	17.1	18.6

The units in the table above are U.S. pounds.

The technology shown in Table 1 results in high amounts of fluorine on the surface of the coating and the high amounts of fluorine are associated with low surface energy, good abrasion resistance, and easy cleaning. As seen in Table I the XPS results for the first 100 angstroms of the top surface vary from about 14 to about 19 atomic percent. Similar recipes wherein the polyoxetane had only hydroxyl end groups have resulted in about 7 to 9 atomic percent fluorine on the surface as determined by XPS. This is significant increase in the surface fluorine content without requiring additional fluorinated oxetane polymer.

While in accordance with the patent statutes the best mode and preferred embodiment have been set forth, the scope of the invention is not limited thereto, but rather by the scope of the attached claims.

**WHAT IS CLAIMED IS:**

1. A reactive polyester resin comprising
  - a) at least one polyoxetane block of repeating units  
5 derived from polymerizing at least one oxetane monomer having at least one pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf group and
  - b) at least one polyester block having a molecular weight above 100 derived from an ester condensation reaction of at least on polycarboxylic acid or an anhydride thereof with at least one  
10 polyol, wherein said polyoxetane block is chemically bonded to said polyester block via an ester linkage derived from a reaction between a hydroxyl group from said polyoxetane block and a carboxylic acid group from either i) said polyester block or ii) a polycarboxylic acid or an anhydride thereof which was a precursor to said polyester block,  
15 wherein said Rf group, independently on each repeating unit, being a linear or branched alkyl group of 1 to 20 carbon atoms with a minimum of 25 percent of the hydrogen atoms of said alkyl group being replaced by F, or said Rf group, independently, being a oxaperfluorinated or perfluorinated polyether having from 4 to 60  
20 carbon atoms, R being hydrogen or an alkyl of 1 to 6 carbon atoms, and n being from 1 to 3.
2. The polyester according to claim 1 wherein said  
25 oxetane block is a copolymer including repeating units from said at least one oxetane monomer and from tetrahydrofuran.
3. The polyester according to claim 1, wherein said at least one oxetane monomer of said polyoxetane block has only one or two pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf group per repeating unit.

4. The polyester according to claim 1, wherein the carboxylic acid reacted to form an ester linkage to said polyoxetane block is a polycarboxylic acid or anhydride thereof which was a precursor to said polyester block.

5

5. The polyester according to claim 4, wherein said polyoxetane block comprises from about 0.05 to about 50 weight percent of said reactive polyester.

10

6. The polyester according to claim 1, wherein said Rf group comprises said linear or branched alkyl of 1 to 20 carbon atoms.

15

7. The polyester according to claim 3, wherein said Rf group comprises said a linear or branched alkyl group of 1 to 20 carbon atoms.

20

8. The polyester according to claim 3, wherein said Rf group comprises a perfluorinated linear or branched alkyl group of 1 to 20 carbon atoms.

9. The polyester according to claim 7, wherein said polyoxetane block includes repeating units from said oxetane monomer and repeating units from polymerizing tetrahydrofuran.

25

10. A process for forming a polyester block or blocks on a preformed polyoxetane polymer comprising;

a) providing a hydroxyl terminated polyoxetane including repeating units derived from polymerizing a monomer or monomers including at least one oxetane monomer having at least one pendant -

30

$\text{CH}_2\text{-O-(CH}_2\text{)}_n\text{-Rf}$  group,

wherein said Rf group, independently on repeating units is

a linear or branched alkyl group of 1 to 20 carbon atoms with a minimum of 25 percent of the hydrogens of said alkyl group being replaced by F or said Rf group independently being an oxaperfluorinated or perfluorinated polyether having from 4 to 60 carbon atoms, R being hydrogen or an alkyl of 1 to 6 carbon atoms, and n being from 1 to 3,

b) reacting a polycarboxylic acid or an anhydride thereof with the hydroxyl group or groups of said hydroxyl terminated polyoxetane under effective reaction conditions to form half ester linkages thereby forming a carboxylic acid terminated polyoxetane,

c) thereafter reacting said carboxylic acid terminated polyoxetane including repeating units from an oxetane monomer having a pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf group with a polyester formed from a condensation reaction or the precursors of said polyester to form a polyester block or blocks on said polyoxetane including repeating units from an oxetane monomer having a pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf group.

11. The process according to claim 10, wherein said hydroxyl group of said polyoxetane is either i) reacted at elevated temperature with said carboxylic acid group or ii) reacted in the presence of a catalyst with said carboxylic acid group.

12. A process according to claim 10, wherein said hydroxyl terminated polyoxetane is a copolymer including repeating units from said at least one oxetane monomer and from tetrahydrofuran.

13. A process according to claim 10, wherein said at least one oxetane monomer of said hydroxyl terminated polymer has one or two pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf group per repeating unit.

14. A process according to claim 10, wherein the carboxylic acid reacted to form an ester linkage to said polyoxetane is a poly-

carboxylic acid or anhydride thereof which was a precursor to said polyester.

15                   15. A process according to claim 10, wherein said poly-  
5   oxetane comprises from about 0.05 to about 50 weight percent of said  
polyester.

10                   16. A process according to claim 10, wherein said Rf  
group comprises said linear or branched alkyl of 1 to 20 carbon atoms.

17. A process according to claim 13, wherein said Rf  
group comprises said a linear or branched alkyl group of 1 to 20 carbon  
atoms.

15                   18. A process according to claim 13, wherein said Rf of  
said repeating units comprises a perfluorinated linear or branched alkyl  
having from 1 to 20 carbon atoms.

20                   19. A process according to claim 17, wherein said hy-  
droxyl terminated polymer includes repeating units from oxetanes and  
repeating units from tetrahydrofuran.

25                   20. A process according to claim 10 wherein the carbox-  
ylic acid groups of said polycarboxylic acid or anhydride thereof are re-  
acted with the total hydroxyl groups in a mole ratio of at least 2:1 and  
less than 0.1 moles of hydroxyls from non-fluorinated polyols are pre-  
sent during said reaction to form a carboxylic acid terminated poly-  
oxetane per mole of hydroxyls from said polyoxetane.

21. A reactive polyester resin comprising

a) at least one polyoxetane block of repeating units derived from polymerizing at least one oxetane monomer having at least one pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf group and

5           b) at least one polyester block having a molecular weight above 100 derived from an ester condensation reaction of at least on polycarboxylic acid or an anhydride thereof with at least one polyol, wherein said polyoxetane block is chemically bonded to said polyester block via a first urethane linkage derived from a reaction  
10       between a hydroxyl group from said polyoxetane block and an isocyanate group from a di or polyisocyanate and a second urethane linkage derived from the reaction of a second isocyanate group from said di or polyisocyanate and either a hydroxyl group from a polyol precursor to said polyester block or a hydroxyl group from a pre-  
15       formed polyester block,

          wherein said Rf group, independently on each repeating unit, being a linear or branched alkyl group of 1 to 20 carbon atoms with a minimum of 25 percent of the hydrogen atoms of said alkyl group being replaced by F, or said Rf group, independently,  
20       being a oxaperfluorinated or perfluorinated polyether having from 4 to 60 carbon atoms, R being hydrogen or an alkyl of 1 to 6 carbon atoms, and n being from 1 to 3.

22. The reactive polyester resin according to claim 21,  
25       wherein said at least one oxetane monomer has one or two pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf groups.

23. The reactive polyester resin according to claim 21,  
          wherein said Rf group comprises said linear or branched alkyl of 1  
30       to 20 carbon atoms.

24. The reactive polyester resin according to claim 21, wherein said polyoxetane block includes repeating units from said oxetane monomer and repeating units from polymerizing tetrahydrofuran.

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25. A process for adding polyester block or blocks on a preformed polyoxetane polymer comprising;

a) providing a hydroxyl terminated polyoxetane including repeating units derived from polymerizing a monomer or monomers including at least one oxetane monomer having at least one pendant -  
10  $\text{CH}_2\text{-O-(CH}_2)_n\text{-Rf}$  group

wherein said Rf group, independently on repeating units is a linear or branched alkyl group of 1 to 20 carbon atoms with a minimum of 25 percent of the hydrogens of said alkyl group being replaced  
15 by F or said Rf group independently being an oxaperfluorinated or perfluorinated polyether having from 4 to 60 carbon atoms, R being hydrogen or an alkyl of 1 to 6 carbon atoms, and n being from 1 to 3,

b) reacting an isocyanate group from a di or polyisocyanate compound with the hydroxyl group or groups of said hydroxyl terminated polyoxetane under effective reaction conditions to form a urethane linkage between the polyoxetane thereby forming an isocyanate terminated polyoxetane,  
20

c) thereafter reacting said isocyanate terminated polyoxetane including repeating units from an oxetane monomer having at least one pendant - $\text{CH}_2\text{-O-(CH}_2)_n\text{-Rf}$  group with a polyester formed from a condensation reaction or the precursors of said polyester to form a polyester block or blocks on said polyoxetane including repeating units from an oxetane monomer having at least one pendant - $\text{CH}_2\text{-O-(CH}_2)_n\text{-Rf}$  group.  
25

30



26. The process according to claim 25, wherein said at least one oxetane monomer has one or two pendant  $-\text{CH}_2-\text{O}-(\text{CH}_2)_n-$  Rf groups.

5            27. The process according to claim 25, wherein said hydroxyl terminated polyoxetane includes repeating units from said oxetane monomer and repeating units from polymerizing tetrahydrofuran.

10           28. The process according to claim 25, where said Rf group comprises said linear or branched alkyl of 1 to 20 carbon atoms.

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## INTERNATIONAL SEARCH REPORT

Intern. Appl. Application No

PCT/US 00/02714

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C08G63/682 C08G18/46 C08G18/42

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 674 951 A (LIVIGNI RUSSELL A ET AL) 7 October 1997 (1997-10-07) claims 1-7	21-28
A	EP 0 348 350 A (CIBA GEIGY AG) 27 December 1989 (1989-12-27) claims 1-17	1-28

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"Z" document member of the same patent family

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Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Decocker, L

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/02714

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5674951 A	07-10-1997	NONE	
EP 0348350 A	27-12-1989	US 4898981 A	06-02-1990
		CA 1338174 A	19-03-1996
		DE 68904479 D	04-03-1993
		DE 68904479 T	29-07-1993
		JP 2097586 A	10-04-1990
		US 4946992 A	07-08-1990
		US 5045624 A	03-09-1991